THE BOGS AND BOG FLORA OF THE HURON RIVER VALLEY.

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(WITH SIXTEEN FIGURES)

[*Continued from p. 375.*]

THE BOG AS A HABITAT FOR PLANTS.

WHEN we consider the bog as a habitat for plants, there is at once brought to mind the marked contrast between its characteristics and those of the other plant habitats of its vicinity. In both its atmospheric and edaphic conditions it is unique. The various factors entering into the plant environment will be discussed as physical, chemical, and biotic agents.

A. PHYSICAL FACTORS.—1. *Wind.*—Because of the fact that so large a number of our bogs lie in depressions surrounded by hills, the influence of the wind is somewhat lessened. It is only in the case of the larger basins that its effects become marked. It has been noted by several students of bogs (**41, 5,** p. 37; **59, 47**) that in the region of prevailing westerly winds the greatest development of bog areas and peat deposits occurs on the western sides of lake basins. Where the deposition has taken place in a large lake basin, which is now only partially filled, we commonly find open water occurring toward the eastern side. The peat deposits at Portage, Parks, and West Lakes in the vicinity of Ann Arbor are massed on the western shores, while the eastern margins exhibit an ordinary lake beach. At the bogs north of Delhi, although nine-tenths of the original basin has been filled, the two small lakes are near the eastern margin. The facts noted in this region all favor the idea of the bog plants being unable to gain a foothold on the eastern side in the presence of wave action. The shoreward thrust of the ice is of importance at times in this connection.

Farther north in Michigan the wind frequently shows its extreme effect in these bog areas in the presence of "windfalls." Owing to the character of the substratum, such areas are more readily affected

than the forests of mineral soils. These phenomena have not been observed in any of the bogs in this vicinity.

The same statement holds for the presence of loose floating bogs which are driven about on lakes by winds (**35**).

2. *Temperature.*—In its temperature relations both the topography and the character of the substratum combine to influence the bog habitat. It has long been noted by agricultural writers that reclaimed bog areas are particularly subject to late frosts in the spring. One of the causes of this peculiarity lies in the fact that on clear and quiet nights the cooled air overlying elevations drains into the depressions (**11**). Some recent observations made by SEELEY (**45**) near Chicago show how effective such atmospheric drainage may be even in districts whose range of elevations amounts to but 15 feet (4.5^m). He found that the hilltop averaged, on the night of the observations, 2.5° F. (1.4° C.) higher than that of the depression while a thermometer placed 30 feet (9^m) above the hilltop averaged 8.8° F. (5° C.) above that of the "swale." On comparing the temperatures of atmospherically undrained and drained depressions with that of the hilltop, he found that the hilltop temperature was 36.3° F. when that of the drained depression was 36° F. and that of undrained 31.8° F. Here is a particular instance in which frost occurred in the undrained depression, but not in the other situations. On quiet nights low grounds in general are subject to lower temperatures than the adjoining highlands, and it is probable that these effects are more pronounced in the case of undrained depressions.

A second factor in the production of low temperatures in bogs is found in the nature of the substratum. In the spring the ice which has formed beneath the cassandra and tamarack areas melts with extreme slowness, when once the surface of the soil has been reached. This is explained by the low conductivity of the loose, partially decayed, vegetable covering, and by the shading of the plants above. For example, at First Sister Lake, in 1904, the ice had disappeared from the water surface on April 10. On April 17, with an air temperature of 10° C., the temperature of the substratum in the bog sedge zone averaged 10° C., in the Cassandra zone 6° C., in the tamarack zone 3° C., and the area of willows and sedges 8° C. Ice was found at several points among the tamaracks, an inch below the

surface. The sedge zone was covered with 1 to 3 inches (25–75^{mm}) of dark colored water. The other soils were wet, but their loose texture was effective in preventing a rise of temperature.

It follows that of the various situations in bog areas those most liable to extreme low temperatures in the spring are in the cassandra and tamarack zone. Since their maximum temperatures are considerably below those of neighboring areas, on quiet nights the plants there are but little protected by radiation from the soil as compared with plants of other situations.

In the following table it is shown that the soil temperatures of the several plant societies formed about a bog are different, and that each society has a characteristic temperature range. The records were made at First Sister Lake. The temperatures, given in °C, are averages of readings made in the second inch (25^{mm}) below the surface. The "willow-sedge" conditions correspond to those of the ordinary swamp. The "maple-poplar" is an area of these trees on the peat substratum. The "upland" is a sandy, sod-covered area 3 feet (0.9^{m}) above the surface of the bog. The temperatures for the most part were taken on clear afternoons about 3 P. M. when the differences are at their maxima.

Date →	April 4	April 12	April 17	April 25	April 29	May 3	May 6	May 16	May 21	May 27	June 6	June 15
Air temperature	10.5	2.0	10.0	8.5	18.0	24.0	27.0	15.0	26.0	21.0	26.0	26.0
Upland	11.0	7.0	10.0	10.0	17.0	20.0	23.0	16.0	20.5	21.5	25.5	26.0
Willow-sedge	7.0	8.0	8.0	9.0	14.5	17.7	19.5	15.0	20.0	22.0	22.0	20.5
Cassandra	1.5	2.0	6.0	7.5	11.0	14.7	15.5	13.0	16.5	19.0	20.0	19.5
Tamarack	0.0	0.0	3.0	4.5	9.9	11.7	15.0	10.6	15.0	17.0	18.0	18.0
Bog-sedge	9.0	8.0	10.0	9.0	18.0	19.0	22.0	16.0	20.0	23.0	24.0	23.0
Maple-poplar	7.0	8.0	8.0	8.0	15.0	18.0	19.0	15.0	16.0	15.0	17.0	16.5

In the accompanying diagram (*fig.* 5) it will be seen that the upland, bog-sedge, and willow-sedge soil temperatures do not deviate widely from those of the air, while the temperatures of the cassandra and tamarack areas range considerably lower. The high temperature of the bog-sedge zone finds its explanation in that the brown bog water overlying its surface absorbs heat. I have tested this point many times in various bogs and have always found such bog water to have a higher temperature than that of the saturated substratum adjoining it. In its ability to absorb heat rays it approaches that of drained sand. Its range, however, is much less and it retains its

heat for a longer time. Consequently on cloudy days and following a sudden lowering of the air temperature, the surface bog-water temperature stands above that of the drained and undrained soil.

When we compare the effects of loss of heat from a free water surface and a saturated humus soil surface due to evaporation, there

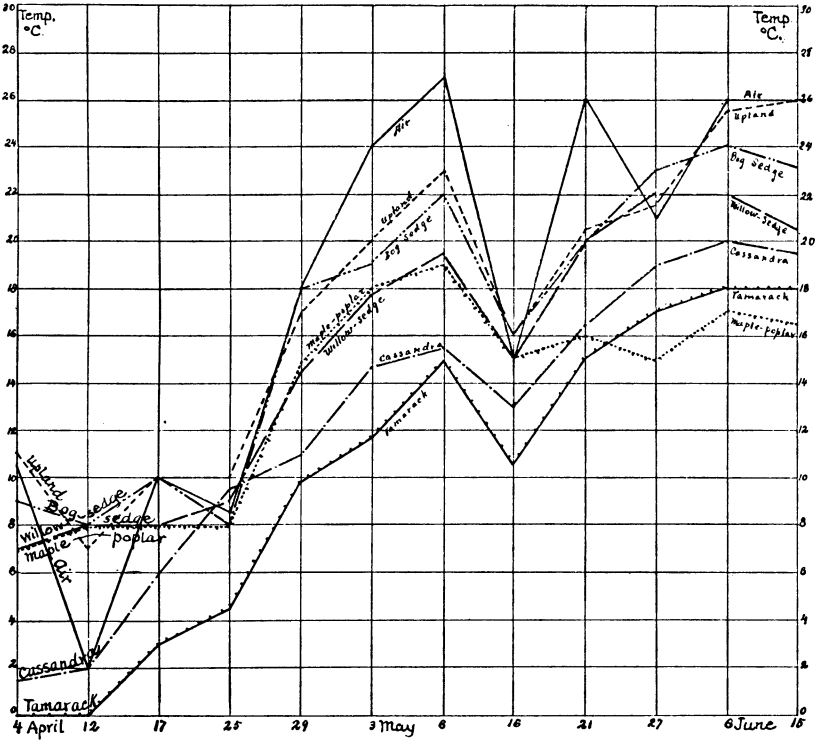

FIG. 5.—Diagram showing temperatures of the air and the substrata in the several plant societies.

is a marked difference due to their specific heat. The humus will be cooled more rapidly by the evaporation of a given amount of water. Where so large an evaporating surface is exposed to the air as in the case of a sphagnum-covered area the loss of heat by this process is most effective in preventing the penetration of heat below the surface.

In the case of drained soils, the most effective agent in raising

the temperature of the subsoil is that of percolating water which has been warmed at the surface of the soil. Because of the high water-table and the stagnant condition of the underground water in bog areas, this source of heat is relatively unimportant.

The effects of these factors, resulting in low soil temperatures, are far-reaching. As compared with well-drained soils, chemical action is retarded, the rate of diffusion, solution, and osmosis is greatly reduced, and the conditions for the existence of soil bacteria made unfavorable. Plants which can successfully compete for the occupancy of such areas must be able to withstand low temperatures and late frosts. The difference between the temperature of the air and that of the substratum favors plants having a low transpiration ratio.

However, in so far as the region of southern Michigan is concerned, the temperatures prevailing in bog areas do not seem to be adequate to account for the presence of the bog plants or their xerophilous structures. It is to be noted that with the leafing-out of the trees, about May 27, the temperature of the maple-poplar substratum falls below that of the tamarack. But that the soil temperature is one of the factors entering into the problem of competition between species there can be little doubt. It is probable also that in the region of optimum conditions for bog plants the conditions which occur here only in the spring are prolonged through the summer. That is, the difference between air and substratum temperatures is more marked, and is a powerful factor in the selection of plants for bog areas and in the production of xerophilous structures.

3. *Texture.*—This property of the substratum has already been referred to in connection with the genetic changes in peat. The sedge zone is developed upon a raft of interwoven rhizomes and roots. It is a coarse meshwork; but since it lies at or below the surface of the water, its texture is of slight importance except as a means of mechanical support. As the bog develops, the admixture of moss and shrub débris brings about the formation of a rather compact peat, overlaid by a stratum of loose material. In some cases, as at Delhi and Oxford, 45 miles (72^{km}) northeast of Ann Arbor, the living sphagnum makes up the bulk of this loose covering. Usually the water level lies just beneath it. As a consequence, this covering becomes the

principal seat of root activity. The small, fibrous roots of cassandra, andromeda, and the cranberry penetrate it in all directions, and it is from the water which is held among this moss and débris that they derive their water and mineral salts.

The substratum beneath the tamaracks is also covered by a loose litter of leaves and twigs, with more or less moss. Depending upon the height above the ground water level, this surface layer is of greater or less thickness. In it occur the wide-spreading roots of the tamarack. During summer and autumn it furnishes admirable conditions for the growth of fungi, and it is penetrated everywhere by their mycelia.

When bog land is cleared, the decomposition of the surface layers is very rapid, owing to exposure to sunlight and higher temperatures. If the water-table is maintained near the surface, sedges and willows develop as the covering. The annual increment of plant material is often decreased, and in place of the fibrous and porous substratum there is produced a black, close-textured, and plastic muck.

If ditching and draining are added to clearing, the summer drought dries the surface layer so thoroughly that it often becomes the habitat for many dry-ground weeds. Decay progresses in moist weather under the influences of the higher temperatures resulting from increased absorption of the sun's energy by the dark colored soil.

4. *Mechanical properties.*—Bog soils in general do not afford as good a foothold for the development of tree species as do the mineral soils. On account of the high water-table, the roots of plants are not able to penetrate to a depth of more than a few inches. The roots of the tamaracks spread out in all directions from a flat trunk base, and upon the size and strength of these horizontal roots depends the tree's ability to withstand mechanical strains tending to displace it. There can be no doubt but that, in the thick groves in which the tamarack occurs, the interweaving of the roots from adjacent trees becomes of mutual advantage, in so far as the roots function as holdfast organs.

5. *Diffusion properties.*—A most important soil property relates to the diffusion of mineral salts. This becomes of especial significance in saturated stagnant substrata. The mineral salts must be distributed to the roots mainly by diffusion, for lateral drainage

and percolation are at a minimum. It is well known that when salt solutions are passed through soil, much of the salt is retained by absorption. The relative amount is greatly increased in the case of humous bodies. BLANCK (**4**) has further found that the diffusion of water in humus soils is decreased by the presence of acid humus compounds, and that this may be corrected by the addition of a neutralizing agent, such as lime. All analyses of peat show how little of this mineral matter has been derived from the adjacent soils. It is only in the case of samples taken from the bottom or edge of a bog that the mineral salts cannot be accounted for by the amount derived from the decay of the plant material, and that obtained from the atmosphere.

6. *Water-capacity.*—The high water-capacity of peat has already been noted. In relation to plant growth, it is detrimental in that it prevents proper aeration of the substratum (**39,** p. 346). So far as the diffusion of gases is concerned, such substrata are less favorable than a free water surface. King (**29,** p. 161), in speaking of sand and clay soils whose water-capacity is only 17.5 to 32.2 per cent. by weight, says that 30 to 40 per cent. of their saturation amounts must drain away before the soil can contain air enough to maintain the respiration of roots and germinating seeds. As compared with a free water surface, saturated humus cannot admit oxygen as freely, owing to the large part of the surface actually occupied by the humus (**29,** p. 239). In a chemical way it is still more effective, as will be noted later.

7. *Osmotic pressure.*—The osmotic pressure of bog waters has been found to be about the same as that of ordinary lakes and rivers.[3] They are approximately equivalent to a 0.1 to 0.5 per cent. normal Knop's solution. They indicate quite certainly that bog plants do not owe their distribution and their peculiar structures to a high osmotic pressure of the bog water.

3 Four samples of bog water from this vicinity were tested by Dr. B. E. LIVINGSTON, of the University of Chicago, and found to have the following pressures in millimeters of mercury at 25° C.:

First Sister Lake, Sample A	50.0742
First Sister Lake, Sample B	40.0593
West Lake, Sample A	100.1484
West Lake, Sample B	150.2226
Lake Michigan water	100.1484

See **33.**

B. CHEMICAL FACTORS.—1. *Ground water.*—The ground water of the Huron basin derives its mineral constituents from the glacial drift. The following analyses show the character of the solution. Quantities are expressed in parts per million (**31**).

	$CaCO_3$	$CaSO_4$	Fe_2O_3	$MgCO_3$	K_2SO_4	SiO_2	NaCl	Na_2CO_3	Na_2SO_4	Organic and volatile	Total mineral matter
Ann Arbor, University well.	178.00	.....	3.99	60.58	6.78	7.30	4.48	1.52	5.07	3.85	267.72
Ann Arbor, spring.....	228.00	.....	6.43	89.36	5.31	9.20	4.88	0.42	9.71	25.00	353.31
Ypsilanti, water works....	289.00	39.00	21.00	100.00	.....	14.00	35.00	.....	.....	71.00	498.00
Ypsilanti, well.....	156.00	223.00	Tr.	109.00	.....	18.00	62.00	17.00	.....	14.00	585.00
Ann Arbor, creek.....	128.00	99.00	Tr.	83.00	.....	25.00	15.00 (NaK)	25.00 (NaK)	.....	14.00	375.00

It is to be noted that they are all high in calcium and magnesium content, and under favorable drainage conditions contain sufficient minerals for plant growth. The ground water is of especial importance in the early stages of bog development, when the sedge and aquatic vegetation is dominant. With the further development of the sedge zone and the formation of a thick peat deposit, its relation to the vegetation becomes of less moment. There is a notable difference between the total mineral content of bog water and that of the soil waters adjoining. In the above table the total mineral content of the ground water varies from 267.7 to 585 parts per million. In three analyses of the bog water at the First Sister Lake I found the total mineral content to vary from 89.9 to 219 parts per million, the highest figure being that for the sample obtained near the margin of the tamaracks, *i. e.*, nearest the mineral soil.

The absence of sphagnum from certain bogs has been explained by the presence of calcium salts (**15**, p. 23, **16**). In order to test this point, I have cultivated the species found in this vicinity in tap water and in a saturated solution of $CaCO_3$, and have found no detrimental effects due to calcium. The experiments will be discussed later. I further found that the ash of sphagnum growing at First Sister Lake contained 18 per cent. of CaO. It would seem, therefore, that, in so far as this vicinity is concerned, the presence of calcareous waters will not explain the absence of species of sphagnum.

2. *Acidity.*—Much stress has been laid by various authors, following SCHIMPER (**44,** pp. 6, 18, 124), upon the acidity of the bog water as a factor in the bog habitat. In order to get a quantitative statement of the acidity for the bogs of this vicinity, a number of 50^{cc} samples have been titrated with an $n/100$ solution of potassium hydrate Phenolphthalein was used as an indicator. The results show an acidity varying from .00015 to .00258 normal acid.[4] The lowest values are found in the areas occupied by bog sedges and by swamp plants, and they are practically the same. The areas occupied by cassandra and sphagnum have a somewhat greater acidity. The highest percentages are found beneath the tamaracks. The explanation of these variations in acidity is suggested by the tests, made from time to time, of the water in my experimental cultures. I found that the acidity of the water increased slowly in the undrained peat substratum cultures (see experiments). The increase was small in the case of the warm cultures, but quite notable in the case of the cold undrained substratum. On exposure to air in the water cultures, and in bottles, the acidity very slowly decreased, the decrease being greatest in the case of the water which was kept warm. This is probably due to increased oxidation. These relative amounts of acid, it will be seen, may be correlated with the temperatures in the several plant societies of the bog, the lowest temperatures corresponding to the highest percentages of acid. This suggests the probability that the acidity of the bog substratum increases farther north.

On allowing open dishes of bog water to stand for some time, I found that the evaporation was not sufficient to raise the acidity of the water, oxidation apparently being more rapid than concentration of the solution.

There is no apparent relation between color and acidity, although the lightest colored solutions usually show but slight acidity. This seems to indicate that only a part of the color is produced by free humus acids, the remainder by humates of the alkalies.

[4] Following are the determinations expressed in fractions of a normal acid solution:

First Sister Lake: sedge zone, .00066, .00094; cassandra zone, .00152, .00119; tamarack area, .00165, .00179, .00227, .00258; willow-sedge area, .00089, .00072.

Chelsea: ditches, .00086, .00015, .00043, .00019, and .00029.

Delhi: tamarack area, .00146, cassandra zone, .00117.

Oxford: cassandra zone, .00094.

The effect of acidity upon cultivated plants has been investigated in this country especially at the Rhode Island Agricultural Experiment Station, under the direction of Professor H. J. WHEELER. The experiments have been conducted upon "acid upland soils" (**60**), and numerous reports have been published. These experiments involved a great variety of plants and were carried on under natural field conditions. The areas planted for comparison had their acidity neutralized by the addition of $CaCO_3$. The plants which were favored by the liming include the orange quince, black Tartarian cherry, Japan plum, *Tilia americana*, *Ulmus americana*, rhubarb, Australian salt-bush, hemp, barley, oats, onions, *Anthoxanthum odoratum*, *Poa pratensis*, *Festuca ovina*, *Holcus lanatus*, *Festuca elatior*, *Alopecurus pratensis*, etc. Plants which appear to be adapted to the acid soil conditions include cranberry, blackberry, raspberry, sheep sorrel, cow-pea, flax, corn, lupine, and soja bean. It would appear, then, that the acidity of the soil solution is unfavorable for the growth of some plants, and that it is a factor in the selection of species for acid soil conditions.

3. *Food material.*—As to the presence of plant food materials in the bog soil there is an agreement among all the analyses that have been made.[5] The soils are unusually rich in nitrogenous materials, some analyses showing three times as much as good upland soils. But in the slow decay of the vegetable matter the nitrogen remains bound up in organic compounds and is unavailable for the growing plants. This is confirmed by experimental tests in which nitrogen was directly applied, and by tests in which the conditions were modified so as to permit the action of nitrifying bacteria. In such cases crops were produced when the untreated humus produced none.

Under natural conditions the growth of the nitrifying bacteria in bog soils is almost impossible. Three factors work against their activity: (1) the acidity of the soil solution; (2) the lack of oxygen due to high water content; (3) the lower temperature. It has been found that the optimum temperature for these bacteria is 98° F. (36.6° C.), and that their activity is very slight at 50° F. (10° C.)

5 Analyses of Wisconsin soils. Ann. Rept. Wis. Agric. Exper. Sta. **13**: 304. 1896. See also **27**, p. 12; **23**; **22**, p. 276; **30**; **48**, p. 234; **12**, p. 39; **14**.

(**3**). Furthermore, it has been shown that when soil rich in nitrogen is saturated with water so as to exclude free oxygen, denitrification takes place and nitrogen gas is set free (**29**, p. 115).

The phosphoric acid content is comparable with that of the best soils, and it is at least partially in a condition for plant use.

The potassium content is very low. Analyses and the results of agricultural experiments show that in order to produce crops this substance must be added, and preferably in an alkaline form. Inquiry among the owners of onion marshes in this vicinity confirms the need for potassium in local bog soils.

The amount of calcium present is reported as equal to that of the best upland soils. But it is probable that as it exists under natural conditions in bogs it is bound up largely in insoluble humates. Under the influence of oxidizing processes it would become available to the plants at the surface.

When we consider the conditions under which the various plant societies in our bogs exist and their competition with one another, there can be little doubt but that the substratum varies in each case as to its chemical composition. That the societies may be classified on a physiographic basis is certain, but how to determine the chemical factors accompanying each physiographic change is an unsolved problem. The ordinary methods of analysis give us the minerals present, but tell us little about their form and availability for plant assimilation. The colorimetric methods for determining the quantity of mineral salts present in bog water are mostly open to objection. The ease with which the humous bodies of the bog water are decomposed render their quantitative estimation by present methods of little value. Yet it seems probable that work upon the chemistry of humus and humous compounds must result in data valuable alike to the ecologist, the forester, and the agriculturist.

C. BIOTIC FACTORS.—The interrelations of the bog species will be discussed in connection with their other ecological characters. It will be sufficient to mention here that they are with a few exceptions light-demanding forms. Consequently, size and ability to produce shade are the important factors in their competition with one another.

A second element enters into this problem of the struggle between

species near the borders of the area of geographic distribution of the bog plants, viz., climate. The bog plants of this vicinity come into conflict with species whose range is either more nearly continental or more southern. That the climatic and edaphic conditions of this region are at present unfavorable to the successful competition of the bog species with swamp species is evidenced wherever the bog conditions have been disturbed. That the reverse is the rule in eastern Canada has been shown by GANONG (**18,** p. 178). The tenacity with which species, whose multiplication is principally accomplished by vegetative means, hold an area under complete control is apparent to any who have studied the vegetation of lake shores. It is just as strongly marked in the case of the herbaceous and shrubby bog vegetation. When we examine the chemical and physical data, now at hand, concerning the soils occupied by bog and swamp plants respectively, the conclusion must be that they are wholly inadequate to account for the difference in vegetation. The forester lays stress upon the fact that trees cannot gain a foothold on areas now covered with a grass turf because of the difficulty of the seedlings getting started. The bog societies form an equally compact plant growth, and their preservation in this region would seem to be dependent upon analogous factors.

III. The bog-plant societies.

The following descriptions of local bog areas occurring in the Huron valley aim not only to present lists of plants found in this vicinity, but to show their natural associations. The order in which the areas are described corresponds to the relative amount of filling which has occurred in the several basins. To a certain extent this order is genetic, yet there can be little doubt but that many arctic plants which were concerned in the pioneer stages of our mature bogs are now extinct. If we accept the areas at West and First Sister Lakes as representing bogs in youth, maturity may be illustrated by the original vegetation of the bog on Carpenter's road. The Chelsea area defines that stage beyond the climax, when the conditions inaugurated by cutting, firing, and ditching have destroyed the original tamarack forest, and in its place has come a rude mixture of bog relicts and arborescent weeds.

WEST LAKE.

This lake, situated three miles north of Chelsea (Sec. 30, Dexter Tp.), is also known locally as Johnson's Lake. In area it is slightly more than a fourth of a square mile (65 hectares). The margin of the lake originally extended a half mile (0.8^{km}) farther west and southwest. This part is now occupied by a partially floating bog. The north, south, and east shores are sandy and low. Patches of bulrushes and water-lilies occur here and there over the lake and show its generally shallow character. Toward the east there is a narrow swampy outlet by which its water after a long and circuitous route reaches the Huron River. There are no streams tributary to the lake. The basin lies near the southeastern margin of the interlobate moraine, and is bounded on the north and south by hills 60 to 80 feet (18–24^{m}) in height. Not all of the original extension to the southwest has been filled by peat; two small areas of open water still remain.

The shores, with the exception of the western side, support a vegetation similar to that of many lakes in this region. Three societies of plants may be distinguished.

Aquatics.—The most abundant plants are Scirpus lacustris, Castalia tuberosa, and Sagittaria rigida. These occur not only along shore, but in shallow water throughout the lake. Associated with these are Naias flexilis, Brasenia purpurea, Potamogeton heterophyllus, Chara (sp.), Spirodela polyrhiza, Vallisneria spiralis, Scirpus americanus, and Decodon verticillatus.

Sedge-grass society.—Very near the north, south, and east shores occur a great number of species of grass-like plants. Their associations vary greatly at different parts of the shore line. The dominant forms are Carex filiformis, Panicularia nervata, Eleocharis palustris, Carex teretiuscula, C. Muskingumensis, Dulichium arundinaceum, Panicularia Canadensis, Dryopteris Thelypteris, and Scutellaria galericulata. Among the species of secondary importance are Onoclea sensibilis, Carex riparia, C. stipata, C. hystricina, C. interior, Spartina cynosuroides, Typha latifolia, Iris versicolor, Lobelia Kalmii, Comarum palustre, Lycopus americanus, and Eupatorium maculatum. Closely associated with these plants are the seedlings of the shrubs and trees which make up the next society.

Willow-maple society.—The shrub and tree border is composed,

for the most part, of Salix Bebbiana, S. discolor, S. sericea, Cornus candidissima, Acer rubrum, and Ulmus americana. Beside the many plants of the sedge-grass society which remain as relicts, the accessory species include Rosa Carolina, Impatiens biflora, Sambucus pubens, Spiraea salicifolia, Prunus serotina, Quercus alba, Q. velutina, and Opulaster opulifolius. These trees grade into the forests of the upland and establish a natural order of succession.

An interesting comparison is afforded when we note the species dominant along the western or bog margin. Here the outer zone of aquatics is made up of the same species, but this substratum is a floating raft constructed by the plants themselves. Without again enumerating the species, we pass to the society which closely follows their development.

Bog-sedge and shrub society.—This society forms a very complex growth, averaging 50 feet (15 m) in width. On the lakeward side are the aquatics; on the other, the growth of tamaracks. The sedges and shrubs are not separable, as in many other localities. Carex filiformis is by far the most important plant in the society. Its vigorous production of rhizomes and roots especially fit it for the position which it occupies. Certain other plants are locally abundant and of great consequence. These include Dryopteris thelypteris, Menyanthes trifoliata, Eleocharis palustris, Comarum palustre, Sagittaria latifolia, Eriophorum polystachyon, Carex teretiuscula, Typha latifolia, Salix myrtilloides, S. candida, Betula glandulosa,[6] Oxycoccus macrocarpus, and Andromeda polifolia. As accessory species may be mentioned Salix discolor, S. Bebbiana, Cicuta bulbifera, Cardamine pratensis, Chamaedaphne calyculata, Campanula aparinoides, Rumex Britannica, Epilobium adenocaulon, Asclepias incarnata, Pogonia ophioglossoides, Blephariglottis blephariglottis, Limodorum tuberosum, Marchantia polymorpha, Aulacomnium palustre, Sarracenia purpurea, Drosera rotundifolia, Boehmeria cylindrica, Carex comosa, C. hystricina, Cornus stolonifera, Parnassia caroliniana, Viola blanda, and Penthorum sedoides. Here and there occur young tamaracks which by their growth inaugurate the next society.

Tamarack society.—As development proceeds, the shrubs and

[6] The form found here and at Delhi corresponds more closely to this species than to *B. pumila*, but its characters are intermediate.

herbs gradually are superseded by a growth of Larix. This society has been much disturbed by lumbering, and a large part of the original area has been cleared. But there is good evidence to show that the part of the basin filled with peat formerly supported a dense covering of tamaracks. Where best developed and least disturbed, it shows an undergrowth of Vaccinium corymbosum, Aronia nigra, etc. As the other species are practically the same as at the lake to be described next, they need not be enumerated here. In contrast with most of the areas studied, the almost complete absence of sphagnum is worthy of note. It is also important that the absence of any gradation between the forest societies of the upland and of the bog be kept in mind.

On this lake, then, there are two divergent series of plant societies. Starting with practically the same species, the one series leads us on mineral soil through willows, maples, and elms to the oaks of the surrounding forests; the other, owing to the development of a floating substratum, involves a very different set of shrubs and ends with the tamarack. The former series therefore more closely approximates the climatic type, while the latter is dependent upon edaphic factors.

FIRST SISTER LAKE.

This lake and its accompanying bog are located three miles west of Ann Arbor in a glacial drainage valley. Its origin is probably connected with the melting of a mass of stagnant ice after the abandonment of the valley by glacial drainage. The surrounding and underlying soil is a sandy gravel. At least a part of the western side presents an original tamarack bog vegetation, and it is particularly interesting in showing the results of competition between bog plants and those of other habitats (*fig. 6*). The vegetation in general presents a different phase of the bog societies, as compared with West Lake. Especially to be noted are the dominance of cassandra and sphagnum in the shrub zone, the absence of cattails and swamp loosestrife as important members of the outer margin. The tamarack zone is also raised somewhat more above the water level.

Aquatics.—With the exception of the shallow-water forms, the lake is almost free of higher vegetation. Potamogeton lucens and P. zosteraefolius occur sparingly. About the margin, however,

Nymphaea advena is of great importance. It forms an almost continuous zone 10 to 25 feet (3–7.5 m) in width. Patches of Castalia tuberosa and Brasenia purpurea occur. This arrangement in groups seems to be connected with their rapid multiplication by rhizomes. Typha latifolia occurs in a small area at the north end of the lake. Ceratophyllum demersum and Naias flexilis occur as secondary species.

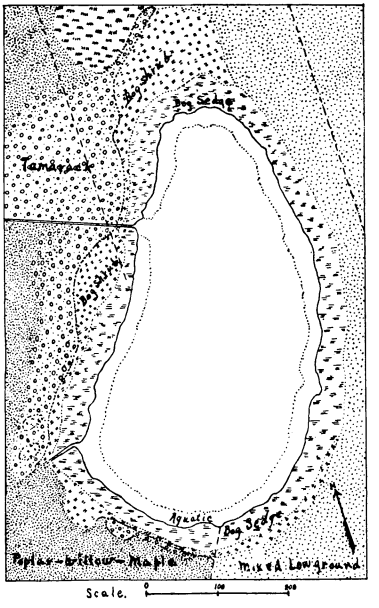

FIG. 6.—First Sister Lake.

Bog-sedge society.—Carex filiformis, C. oligosperma, Eleocharis palustris glaucescens,. and Eriophorum polystachyon are the primary factors in the formation of this zone. Carex riparia has gained a foothold at the north end of the lake, where muskrats have been active in destroying the original sedge zone. Dryopteris thelypteris, Onoclea sensibilis, Juncus effusus, J. canadensis, Comarum palustre, Salix myrtilloides, Dulichium arundinaceum, Equisetum fluviatile, Bidens trichosperma tenuiloba, Menyanthes trifoliata, Viola blanda, and Eriophorum virginicum occur as accessory plants. The great majority of these plants aid in the construction of the substratum by their roots and rootstocks.

Here and there among the sedges occur the forerunners of the shrub society. Among the very first to gain a foothold are the sphagnums. These build small tufts of great compactness, and gradually overcome the sedges. The rootstocks of the cassandra also send up shoots and prepare the way for another vegetation form. Oxycoccus macrocarpus and O. Oxycoccus both occur at intervals in this zone.

Cassandra-sphagnum society.—Beyond the sedge zone the vegetation is no longer arranged zonally. Conditions have been so much

disturbed that on the western side the area of cassandra-sphagnum dominance is very irregular. On the eastern side this plant society is in the last stage of its existence. The intimate association of Chamaedaphne calyculata, Sphagnum cymbifolium, S. subsecundum, and S. recurvum is well illustrated here. The plants occupy the whole of the territory where they flourish. The other species are decidedly secondary. It is to be further noted that in the competition with the sedge species these plants actually override them, and only an occasional Eriophorum virginicum survives. The water-conserving properties of the sphagnum are too well known to need description here. But the mutual advantage of the cassandra-sphagnum combination is worthy especial note. The former by its numerous branches furnishes a framework which aids in the upbuilding of the moss and in shading. The sphagnum, on the other hand, furnishes a moist cover in which the conditions for the shrub are most favorable.

The accessory species include the moss, Aulacomnium palustre; the herbs, Drosera rotundifolia, Arethusa bulbosa, Habenaria lacera, Sarracenia purpurea, Pogonia ophioglossoides, Limodorum tuberosum, Viola blanda, Osmunda regalis, Campanula aparinoides, Scutellaria galericulata; and the shrubs, Andromeda polifolia, Betula pumila, Oxycoccus macrocarpus, O. Oxycoccus, Aronia nigra, and Ilicioides mucronata.

Tamarack society.—Among the cassandra occur many young tamaracks, and these by their development come to overshade the shrubs and form the tree society of the bog. The dead remnants of the cassandra mounds make up a large part of the floor beneath them. The species of secondary importance are Ilicioides mucronata, Aronia nigra, Chamaedaphne calyculata, Osmunda cinnamomea, O. regalis, Dryopteris spinulosa intermedia, D. cristata, Polytrichum juniperinum, Plagiothecium denticulatum, Thuidium recognitum, Aulacomnium palustre, Marchantia polymorpha, Sphagnum cymbifolium, Boletinus porosus, and Thelephora intybacea.

The tamarack zone has been much disturbed by clearing and burning. At the present time a large part of the area on the southwest side is dominated by other tree species. Some of the plants of the clearing have spread into the pure tamarack growth.

Poplar-willow-maple society.—Where the original conditions have been disturbed and a second growth allowed to come in, Populus tremuloides, Salix sericea, Salix discolor, and Acer rubrum have obtained dominance. Where groups of the more mature poplars occur there is scarcely any undergrowth. Elsewhere the following plants occur: Ilicioides mucronata, Salix Bebbiana, Sambucus pubens, Amelanchier oligocarpa, Aronia nigra, Rubus nigrobaccus, Cornus stolonifera, and Rubus strigosus. These form a dense mixed association, with but slight reference to substratum conditions. The smaller species present are Adicea pumila, Osmunda cinnamomea, Rosa Carolina, Onoclea sensibilis, Epilobium adenocaulon, Spiraea salicifolia, Dryopteris thelypteris, Verbena hastata, Solanum dulcamara, Polygonum sagittatum, Spiraea tomentosa, Geum rivale, Polygonum hydropiperoides, Ribes floridum, Ribes oxyacanthoides, Rumex Britannica, Impatiens biflora, Viola blanda, Osmunda regalis.

On the southeast side of the lake and on the north, conditions have been still more interfered with, and there is now a mixed growth of bog and low-ground plants, which represent stages in the decline of the bog flora and the advent of swamp plants. The tallest forms are willows and clumps of mountain holly. For convenience only, the plants may be enumerated together under the following title:

Mixed low-ground society.—The dominant plants are Salix sericea, S. discolor, Spiraea salicifolia, Poa flava, Solidago serotina, Chamaedaphne calyculata, Oxycoccus macrocarpus, Aster Novae-Angliae, and Rosa Carolina, Epilobium adenocaulon, Aronia nigra, Andromeda polifolia, Rubus strigosus, Dryopteris thelypteris, Scutellaria galericulata, Juncus effusus, Koellia virginiana, Sambucus canadensis, Geum rivale, Osmunda regalis, Scirpus cyperinus, Galium aparine, Homalocenchrus oryzoides, Juncus tenuis, Asclepias incarnata, Salix Bebbiana, Eupatorium perfoliatum, Gentiana Andrewsii, Lycopus virginicus, Osmunda cinnamomea, Cornus stolonifera, Carex riparia, Viola blanda, Sarracenia purpurea, Dryopteris cristata, D. spinulosa intermedia, and Triadenum virginicum also occur.

The last two societies are found upon a black peat substratum which is more thoroughly decayed than in other parts of the bog.

Acidity tests show that the relative acidity is less than in the case of the cassandra-sphagnum and tamarack societies. The soil temperature also runs somewhat higher as noted elsewhere.

The First Sister Lake may be said to be dominated by three well-marked bog and two mixed societies in which bog and swamp species are brought into competition. The result can be foretold with considerable certainty. The bog vegetation will sooner or later be replaced by the swamp species.

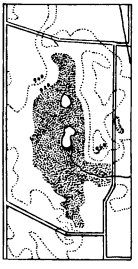

FIG. 7.—Delhi bog and adjacent topography. Scale 1:95,000 ($\frac{2}{3}$ inch = 1 mile).

BOG NORTH OF DELHI.

Two miles north of Delhi occurs an extensive bog which was formerly a mile and a quarter (2 km) long by a half mile wide (0.8 km) at its broadest part (*fig. 7*). The southwestern third has been cleared and is in part under cultivation. The eastern and northern parts have been somewhat interfered with by the cutting of timber, but areas occur which have been but little disturbed by these influences. Near the eastern margin are two small lakes, the last remnants of the larger lake which must have occupied this territory in early postglacial times. The basin is located in a clay moraine of the Erie ice-lobe, and probably owes its origin to unequal deposition by the glacier.

The plant societies found about the southeastern lake will give an idea of the whole vegetation (*fig. 8*).

Aquatic society.—The aquatic vegetation is represented almost wholly by the yellow water-lily, Nymphaea advena. This plant forms a broader zone completely encircling the lake and varying from 5 to 10 feet (1.5–3 m) in width. Accompanying it occur Brasenia purpurea, Ceratophyllum demersum, Lemna minor, and Spirodela polyrhiza.

Typha-cassandra-sphagnum society.—On the floating margin of the bog substratum occurs a zone which partially encircles the lake. Near its outer edge Typha latifolia is the characteristic plant, but in certain places it is wanting or extends the full width of the zone. Chamaedaphne calyculata, Sphagnum cymbifolium, S. subsecundum, S. recurvum, Carex filiformis, Eriophorum polystachyon, and Salix

myrtilloides are the most frequent plants. The accessory species include Carex oligosperma, Menyanthes trifoliata, Comarum palustre, Triadenum virginicum, Osmunda regalis, Onoclea sensibilis, Rumex Britannica, Asclepias incarnata, Viola blanda, Cicuta bulbifera, Galium Aparine, Scutellaria galericulata, Rhus Vernix, Dulichium arundinaceum, Oxycoccus macrocarpus, Hypnum cordifolium, Hypnum Schreberi, Aulacomnium palustre, and Mnium.

Vaccinium-aronia society.—Forming a narrow transition society between the low shrub zone just described and the tree society, occurs a dense line of tall shrubs. The dominant species are Vaccinium corymbosum, Gaylussacia resinosa, Aronia nigra, Ilicioides mucronata, Betula glandulosa, and Prunus serotina. The other species present are Acer rubrum, Sambucus pubens, Osmunda cinnamomea, Salix discolor, S. Bebbiana, Spiraea salicifolia, Ilex verticillata, Rosa Carolina, Sarracenia purpurea, Andromeda polifolia, Calamagrostis canadensis, and Eleocharis palustris glaucescens. These shrubs border the tamaracks and to varying distances extend back among them.

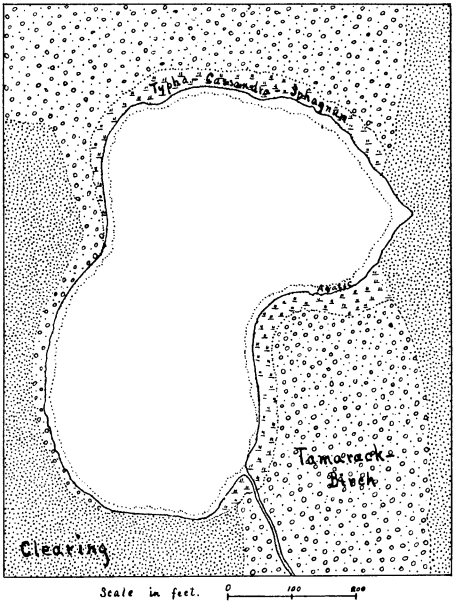

FIG. 8.—Portion of Delhi bog.

Tamarack-birch society.—Larix laricina and Betula lutea must have made up the great bulk of the original forest which occupied this area. The relative abundance of the latter has probably been increased by the cutting of the tamarack. The next most important tree is Acer rubrum, which occurs scattered throughout, but is especially abundant near the northeast side. Where isolated trees have been removed, the shrubs which occur among the undergrowth have

made a rapid growth. Throughout the forest area are patches in which Aronia nigra, Vaccinium corymbosum, and Ilicioides mucronata stand so thickly as to be almost impenetrable. Where the forest has been but slightly disturbed and the tamaracks are more or less scattered, one finds a deep carpet of sphagnum with slender stems of cassandra, andromeda, and Eriophorum virginicum rising through it. Clusters of Sarracenia purpurea are common. The other plants found in this society are Trientalis americana, Unifolium canadense, Coptis trifolia, Rumex Acetosella, Rubus strigosus, Dryopteris spinulosa intermedia, Osmunda cinnamomea, Viola blanda, Impatiens biflora, Solanum dulcamara, Thelephora intybacea, Polytrichum juniperinum, Sambucus pubens, Agrostis alba, Blephariglottis lacera, Cornus candidissima, and Cicuta maculata.

Clearing society.—Surrounding the forest on the east, south, and west sides is a large area, in part dominated by sedges and grasses, and in part by a typical "slashing." It is impossible to characterize this plant association by any particular species. All that have been thus far mentioned occur in scattered clusters, the proportions and dominant plants varying from one locality to another. The notable facts are that on the east side Carex teretiuscula, C. vulpinoidea, C. riparia, C. filiformis, Scirpus cyperinus, Calamagrostis canadensis, Aster Novae-Angliae, Eupatorium perfoliatum, and Aster junceus have become the most abundant forms. To the west of the lake these plants are present, but the taller shrubs are in control. Salix discolor, Cornus stolonifera, Salix Bebbiana, S. sericea, and many others already mentioned as occurring among the tamaracks are present.

The second lake and the more northerly one is bordered by an exceedingly narrow zone of low-growing plants. The dominant species are Decodon verticillatus and Typha latifolia. Chamaedaphne calyculata, Carex riparia, Panicularia canadensis, and Bromus Kalmii are of secondary importance. The trees come almost to the water's edge. The proportion of red maples among the tamaracks and birches is considerably greater than in the vicinity of the other lake. Otherwise the tree society is essentially the same.

We have illustrated, then, in the bogs at West Lake, First Sister Lake, and Delhi, three stages in the filling of old lake basins. We

have seen that, although there are minor variations in the species present, all of the bogs show a series of bog-sedge, shrub, and conifer societies which are genetically related. In the Delhi bog the filling is almost completed. In the bog about to be described we find this process finished, and what was formerly a ring of bog-sedges surrounding an open lake has become an irregular disk forming the central plant society of the area.

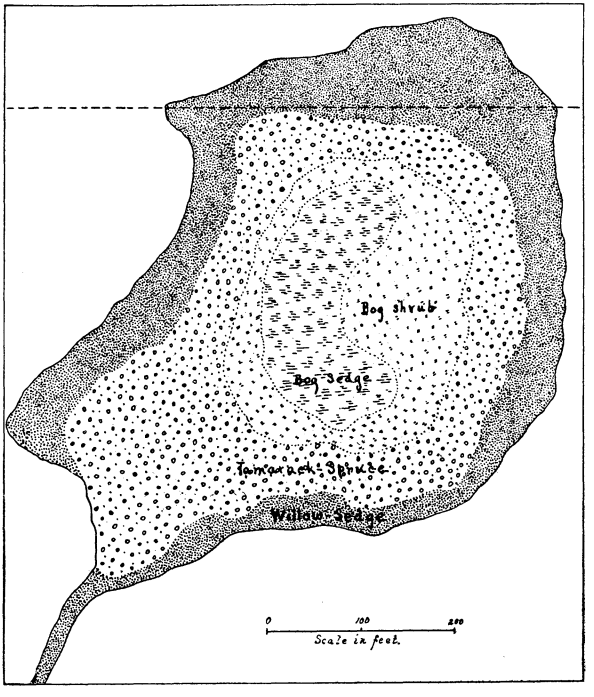

FIG. 9.—Bog near Oxford, Oakland county.

BOG NEAR OXFORD, OAKLAND COUNTY.

Near the northeast corner of Sec. 31, Oxford Tp., there is a bog (*fig. 9*) covering about 4.5 acres (1.8 hectares). Although it lies a few miles beyond the real boundary of the Huron River basin, it is included because it exhibits a flora somewhat different from the other areas, and may be considered as a near approach to the type of bogs occurring farther north. The basin is a depression in the outwash sands and gravels of the interlobate moraine. It is sur-

rounded by hills 25 to 30 feet (7.5–9^{m}) in height above the bog level. During wet weather it has a shallow outlet to the southwest. The land surrounding it has all been cleared and is now under cultivation. As shown by other timber areas in the vicinity, it is probable that the original upland timber was made up in part of Pinus strobus, Quercus coccinea, and Betula papyrifera.

Bog-sedge society.—Toward the center of the bog is a considerable area in which the water level lies just at the surface. The sphagnum is for the most part submerged, and the dominant plants are Carex oligosperma and Scheuchzeria palustris. Occasional plants of the following society are scattered throughout.

Bog-shrub society.—While this zone is characterized by Chamaedaphne calyculata, Sphagnum cymbifolium, S. recurvum, and S. subsecundum, young and dwarfed specimens of the spruce, tamarack, and pine are present in large numbers. The surface formed by the sphagnum is exceedingly rough and marked by hummocks. Among the depressions Eriophorum virginicum, E. vaginatum, Andromeda polifolia, Sarracenia purpurea, and Oxycoccus macrocarpus are abundant.

Tamarack-spruce society.—This society forms a zone completely surrounding the shrub society, and is dominated by trees of Larix laricina and Picea Mariana. Occasional specimens of Pinus Strobus are found, especially toward the southwest corner, where the substratum is somewhat higher than elsewhere. Beneath the trees is an almost impenetrable tangle of shrubs, especially Vaccinium corymbosum and Ilicioides mucronata. The substratum is practically bare of lower vegetation. An occasional mat of Aulacomnium palustre may be found at the tree bases. That this society will come into possession of the central bog area is certainly indicated by the great numbers of young trees among the bog shrubs.

Willow-sedge society.—As usual in the clearing of the adjacent land, the larger trees of the bog margin were also removed, and in their stead has come up a growth of willows. The dominant plants of this zone are Salix sericea, Cornus stolonifera, Spiraea salicifolia, Salix discolor, Carex riparia, and C. stipata. Associated with these plants are Sambucus pubens, Salix nigra, Iris versicolor, Populus monilifera, Dryopteris spinulosa intermedia, Osmunda cinnamomea,

Equisetum limosum, Cornus candidissima, Aronia nigra, Rosa Carolina, Juncus effusus, Calamagrostis canadensis, Rubus strigosus, Ilicioides mucronata, Comarum palustre, Carex filiformis, Panicularia canadensis, and Poa flava. Forming a high border about the tamaracks and spruces are numerous large plants of Vaccinium corymbosum and Ilicioides mucronata.

The very marked difference between the vegetation of the central and marginal parts of the bog are worthy of especial note. The former represents the original vegetation of the bog. The latter illustrates most forcibly that under present conditions a very different set of plants springs up and becomes dominant, in spite of the fact that the true bog plants were near at hand when the clearing occurred. This bog also illustrates that stage in the filling of a depression immediately following the disappearance of the lake.

In other bogs near Oxford, Dasyphora fruticosa and Chiogenes hispidula occur among the shrubby growth.

THE DELHI MUSKEAGS.

In the bog north of Delhi which has already been described occur two areas, somewhat to the west of the lakes, which seem to represent a later stage in the history of a bog than that shown by the lakes. These areas, if they were found in northern Michigan, would be termed "muskeags." They are surrounded by large tamaracks, and small tamaracks occur throughout, the smallest specimens toward the center. If the bog at Oxford were to continue its work of filling until the central society disappeared, we should have a bog area of much the same appearance. The small tamaracks stand far apart, and between them is a most luxuriant growth of cassandra and sphagnum. The hummocks rise between 3 and 4 feet (0.9–1.2^{m}) above the substratum. As one attempts to traverse these areas, he sinks knee-deep in the long, fibrous, peat moss.

The total number of species is very small, and includes, besides those already mentioned, Andromeda polifolia, Sarracenia purpurea, Oxycoccus macrocarpus, and a few specimens of Vaccinium corymbosum.

BOG ON CARPENTER ROAD

This bog is situated in the SW. ¼ Sec. 36, Ann Arbor Tp. Its basin is a small depression in the glacial moraine occupying about

one-tenth of an acre (*fig. 10*). On the south, west, and north sides it is bordered by clay hills which rise 25 to 40 feet (7.5–12^{m}) above the bog level. The vegetation of the hills is dominated by Quercus velutina, Q. alba, and Q. rubra. With these trees occur Hicoria ovata, Hamamelis virginiana, etc.

On the north side the upland has been cleared, and the land is now under cultivation. From time to time tamaracks have been removed from the bog, until at the present time only the central area remains to indicate the original covering. Accompanying the clearing there has grown up about the tamaracks the usual thicket of shrubs and young trees. As elsewhere, the peat is more thoroughly decayed and the substratum level somewhat lower about the margin than toward the center. This fact is of importance in differentiating the willow-sedge society.

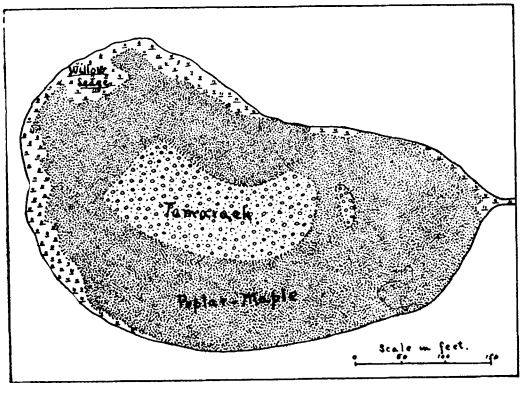

FIG. 10.—Bog on Carpenter road.

Tamarack society.—This society is dominated by the group of rather mature tamaracks. The substratum has the characteristic hummocky surface, marked by large exposed roots, common to such areas. It is overlaid by a loose covering of vegetable matter, made up principally of tamarack needles. The undergrowth is sparse, but most of the bog shrubs and herbs are represented. The more important species are Chamaedaphne calyculata, Sphagnum cymbifolium, S. recurvum, S. subsecundum, Eriophorum virginianum, and Lycopus virginicus. A very noticeable growth about the bases of most of the shrubs is produced by the fungus, Thelephora intybacea. The mycelium in developing its sporophores rises about the stems, frequently to a height of a foot (25^{cm}). From the cylinder thus formed, irregular fan-shaped pilei are developed, which gives

the appearance of an elongated brown rosette about the stem bases. Clitocybe laccata and Boletinus porosus are also abundant in the autumn. The partially decayed stumps bear Peltigera canina. Other species occur in this area, but reach their dominance in the next society.

Poplar-maple society.—Here are brought together the remnant of the bog species, and those more characteristic of swamps and clearings. The trees are mainly Populus tremuloides, with a scattering of Acer rubrum. Elm seedlings occur. The shrubby plants, however, make up the bulk of the vegetation. Ilicioides mucronata, Ilex verticillata, Aronia nigra, and Vaccinium corymbosum have almost complete possession, and are struggling with one another for space. All these forms send up stems from the underground parts, so that among them the struggle is largely a mechanical one. However, where the red maple overtops them, the factor of shade enters, and the black choke-cherry and high-bush blueberry are the most tolerant. The mountain holly and black alder prevail elsewhere. The next most important plants are the willows, Salix sericea and S. discolor. Mixed with these are Cornus candidissima, Rubus nigrobaccus, Rosa Carolina, Cornus stolonifera, Spiraea salicifolia, and Rubus strigosus.

Willow-sedge society.—The area dominated by these plants is covered with water in the spring and during moist weather. Although this society is fast being crowded out by the next preceding, it is probable that only a small part of that area was ever occupied by these plants. These plants require a more moist substratum. The dominant species are Salix sericea, Carex riparia, C. stipata, Cornus stolonifera, and Osmunda cinnamomea. In the case of the cinnamon fern found in this bog there is a remarkable development of aerial roots. They are about an inch long and extend outward from the thick rootstock in all directions, forming a dense covering. The roots are thickly covered with root-hairs which have been persistent at least through one winter. The root-hairs are large and brown in color. The appearance of these rootstocks, as a whole, is very suggestive of certain tropical tree ferns. The other species present are Ranunculus abortivus, Polygonum sagittatum, Cicuta bulbifera, Prunella vulgaris, Rubus americanus, Rhus Vernix, Solanum dulca-

mara, Impatiens biflora, Eupatorium perfoliatum, Calamagrostis canadensis, Dryopteris thelypteris, D. spinulosa intermedia, Doellingeria umbellata, Lactuca spicata, Coptis trifolia, Boehmeria cylindrica, Onoclea sensibilis, Marchantia polymorpha, and Rosa Carolina.

The further development of these societies under present conditions will bring about a complete change. There can be no doubt that the poplars and red maples are the coming trees, with elm a close third. When these have become sufficiently large and numerous to overshade the shrubs, the latter will be killed out, and we shall have in their place the maple-elm forest common to the low grounds. The shrubs, however, are capable of persisting for a great length of time, because of the difficulty of tree seedlings obtaining a start beneath them.

THE CHELSEA BOG.

Of the bogs which have been subjected to clearing, burning, and ditching, by far the most interesting in this region is located just to the southeast of the town of Chelsea. It covers an area of about 50 acres (20 hectares), and the peat is reported to be 40 feet (12^m) thick at the deepest places. The divisions into societies, as indicated on the map (*fig. 11*), are based on the most general characters of the vegetation. There are gradations between all of the societies, and these are so gradual that it is difficult to determine definitely the boundaries. Further, owing to the tendency of many of the shrub species to form dense local growths by the development of stems from underground shoots, the smaller associations are very diverse in different parts of the same society.

Birch-vaccinium society.—This mixed society of bog shrubs occupies about one-fourth the area of the bog. Its substratum consists of peat standing about a foot above the average water level. The dominant plants are Betula pumila, Vaccinium corymbosum, Rubus frondosus, Aronia nigra, Vaccinium canadense, and Pteridium aquilinum. Just as common perhaps, but of lower growth, are Rubus hispidus, Spiraea salicifolia, S. tomentosa, Aralia hispida, Chamaedaphne calyculata, and Rumex Acetosella. The ground covering, except beneath the dense shade of the shrubs, is made up of Polytrichum juniperinum. There are many small areas of which this plant now holds exclusive control, and forms a rich carpet of

green, yellow, and red, depending upon the season of the year. Where the moss is disturbed by the uprooting of plants, the substratum becomes exceedingly dry. The moss dies out, and in place of it there springs up a growth of Cladonia rangiferina, C. pyxidata,

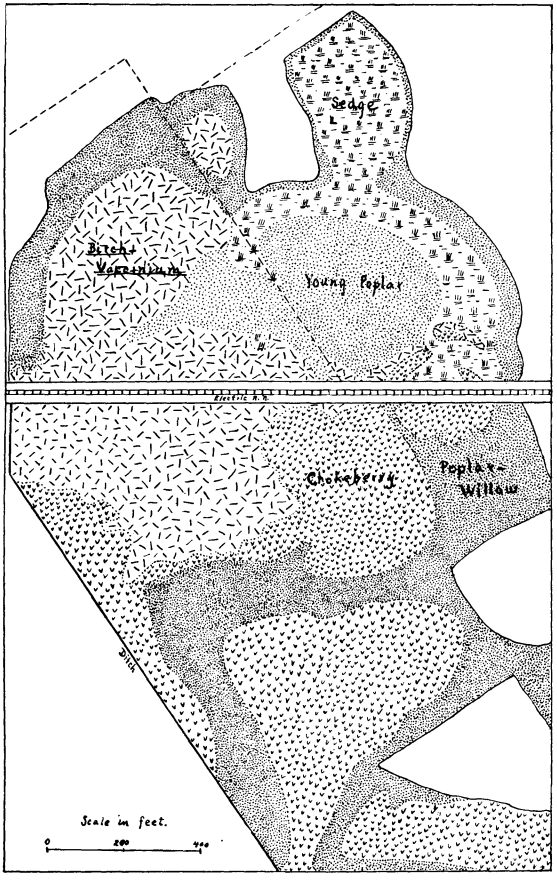

FIG. 11.—Chelsea bog.

C. gracilis, C. verticillata, C. cristatella, and frequently a small admixture of Rumex Acetosella. These plants gradually close over the surface and aid in the conservation of the moisture. As the conditions become more favorable, the Polytrichum again closes over the area, driving out the lichens. About the borders of the shrubs

the Polytrichum is killed out by the shade. Rumex Acetosella is better fitted to withstand such conditions, and consequently forms an inner border about each group of shrubs. Where depressions occur and are flooded for any length of time, the Polytrichum is replaced by Eriophorum virginicum and Scirpus cyperinus. Along the northwestern border Rubus nigrobaccus is making inroads upon this society. To the north of the railroad, however, the most important changes are being wrought by the development of Populus tremuloides and Quercus velutina. Young trees of the former are now scattered throughout, while the latter is present in small number. The plants of minor importance are Ilex verticillata, Viburnum lentago, Ilicioides mucronata, Amelanchier Botryapium, Euthamia graminifolia, Doellingeria umbellata, Bidens trichosperma tenuiloba, Dulichium arundinaceum, Poa flava, and Sphagnum cymbifolium.

Chokeberry society.—Aronia nigra forms the most dense and exclusive growth that occurs on the bog. Usually the substratum is somewhat lower and more subject to overflow than in the last society. It would seem from observation that this condition is in part due to the chokeberry itself. Owing to its dense growth, it protects the surface of the peat from drought and favors the processes of decay. At the same time it adds very little to the substratum in the way of débris. Where it attains its best development it is practically without undergrowth. About the borders it is mixed with Vaccinium corymbosum, Betula pumila, and Ilex verticillata. Of the smaller plants, Pteridium aquilinum penetrates to the greatest distance. Other species occurring about the borders are mentioned among the other societies.

Poplar-willow society.—About the borders of the bog, and extending to a greater or less extent into its interior, is a dense zone composed of Populus tremuloides, Salix discolor, Quercus velutina, Populus grandidentata, and Salix nigra. By far the most abundant form is the trembling aspen. The substratum varies from areas well above the water level to areas which are constantly submerged. The spen is also the most important of the plants which are invading the shrub societies. In the relative proportion of the individual species there is the greatest variation at different places in this border zone. Of the more enduring species, Quercus velutina is the most abundant. The other species present are Salix Bebbiana, S. sericea, S. lucida,

Prunus serotina, Quercus alba, Q. macrocarpa, Acer rubrum, Betula lutea, Amelanchier Botryapium, Viburnum pubescens, Spiraea salicifolia, S. tomentosa, Corylus americana, Sambucus pubens, Cornus candidissima, C. stolonifera, Cicuta maculata, Aster lateriflorus, Carduus altissimus, Galium asprellum, Osmunda cinnamomea, O. regalis, Ranunculus pennsylvanicus, Calamagrostis canadensis, Viola blanda, Euthamia graminifolia, Bidens frondosa, and Aster Novae-Angliae.

Sedge society.—On the northeast side of the bog is an area dominated by sedges. In the fall of the year it appears to be a uniform area of Scirpus cyperinus, but there are many other species mixed with it. The substratum is low and is mainly characterized by tussocks formed by the sedges. Throughout, occur small clumps of the willows already mentioned. The most abundant accessory species are Isnardia palustris, Calamagrostis canadensis, Carex teretiuscula, C. stipata, C. filiformis, C. fusca, C. oligosperma, C. riparia, and Aulacomnium palustris.

The future flora of this bog appears to be indicated by the rapid growth of the poplars, willows, and oaks. The few tamaracks remaining are approaching maturity and are not being reproduced. The means by which these tree species combat the shrubs is mainly by shading, while the latter in the same way interfere with the development of the tree-seedlings. The time involved in this struggle must be very great, but the ultimate outcome will be an oak forest, the intervening stages being filled in by poplar and willow growths. If, however, the decay of the peat beneath these trees brings the surface to the water level, the poplar-willow stage will be indefinitely prolonged.

GENERAL CONSIDERATION OF THE BOG FLORA.

Beside the trees mentioned in the preceding descriptions, note should be made of the occasional occurrence of the black ash, Fraxinus nigra, and swamp white oak, Quercus platanoides, in bog areas. It frequently happens, when the tamaracks are cut, that the black ash becomes abundant, as in the area one-half mile southeast of Kavanaugh Lake, where it is now associated with Ulmus americana and Acer rubrum. Another example occurs about a mile north of Chelsea in the NE. ¼ Sec. 1, Sylvan Tp. Here in a small area from which the tamaracks were removed, Fraxinus nigra, Quercus platanoides,

Fraxinus americana, F. pennsylvanica, Acer rubrum, Ostrya virginiana, Tilia americana, and Liriodendron tulipifera are associated. The undergrowth consists of Solidago patula, S. neglecta, Aster lateriflorus, Mitella diphylla, Euonymus obovatus, Viola pubescens, Agrimonia hirsuta, Cornus florida, C. candidissima, Eupatorium perfoliatum, Rosa Carolina, Viburnum Lentago, Juniperus communis, and Spiraea salicifolia. The substratum is almost entirely occupied by mosses, including Hypnum fluitans, H. Schreberi, H. Blandovii, H. roseum, Thuidium recognitum, and Climacium americanum.

On the farm of James Barton (SW. ¼ Sec. 2, Lyndon Tp.) the black ash, red maple, and American elm have replaced a former growth of tamaracks and black ash.

In a previous publication (**55**: p. 403) the writer called attention to the absence of a genetic relationship between the bog plants and the surrounding vegetation in southern Michigan. This was explained on the basis that the bog vegetation is a relict of former climatic conditions; that it has a genetic relationship with the conifer forest formation of northeastern North America, as shown by studies in northern Michigan and Pennsylvania, and that in this region it has been surrounded by a more southern flora whose center of distribution is the southeastern United States. Consequently no order of succession between the tamarack and the oak floras is to be expected.

When, however, bog areas are cleared or their normal development disturbed, such trees as the black ash, white ash, red maple, and elm replace the tamarack, and a definite order of succession is established.

It was also maintained that present bog habitats are continuations of similar habitats which came into existence when a colder climate prevailed than at present. More recent observations tend to confirm and strengthen this statement.

The dominance of bog and swamp plants respectively in adjoining areas is to be explained largely by the time when the areas came to support their present ground vegetation. If the habitat has existed undisturbed since the time when a colder climate prevailed, the bog plants will be dominant. If it came into existence in recent times, or has been disturbed, it will be dominated by swamp species.

(*To be concluded.*)